CAPSTONE PROJECT

PREDICTIVE MAINTENANCE OF INDUSTRIAL MACHINE USING MACHINE LEARNING

Presented By:

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OUTLINE

- Problem Statement
- Proposed System/Solution
- System Development Approach
- Algorithm & Deployment
- Result (Output Image)
- Conclusion
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PROBLEM STATEMENT

- In industrial environments, machinery failures often result in unplanned downtimes, reduced productivity, and increased maintenance costs. Traditional preventive maintenance techniques rely on fixed schedules and are often ineffective in predicting unexpected failures.
- There is a growing need for intelligent systems that can analyze real-time sensor data and detect anomalies or patterns that lead to machinery failure. The core problem lies in the inability to anticipate the type and timing of failures, which limits proactive intervention and disrupts operational efficiency.

PROPOSED SOLUTION

To address this issue, we propose a machine learning-based classification model that can predict the specific type of failure before it occurs, using historical sensor data from industrial machines. This model will be developed and deployed using IBM Watsonx.ai Studio.

Key objectives include:

- Analyzing historical machine data from various sensors
- Training a classification model to identify failure types
- Deploying the model as a web service for real-time inference
- Evaluating the model with metrics to ensure reliability and performance

SYSTEM APPROACH

The **"System Approach"** section outlines the overall strategy and tools used for developing and implementing the predictive maintenance model to classify industrial machinery failures.

System Requirements

- **Platform:** IBM Watsonx.ai Studio (Free Tier)
- **Environment:** AutoAI (AutoML interface within Watsonx.ai Studio)
- **Deployment:** IBM Watson Machine Learning (WML) for publishing the model

ALGORITHM & DEPLOYMENT

This section describe the machine learning algorithm chosen for predicting the **type of machinery failure**. Here's the structured overview:

Algorithm Selection:

- The **Snap Random Forest Classifier** was selected by AutoAI after evaluating multiple algorithms.
- It was chosen based on its high accuracy (99.5%) and ability to handle multiclass classification effectively.
- Other explored models included the Snap Decision Tree Classifier, but Random Forest outperformed in cross-validation.

Data Input:

- The model was trained on labeled historical sensor data with the following input features:
  - Air Temperature, Process Temperature, Rotational Speed, Torque and Tool Wear
  - The target variable was **Failure Type.**

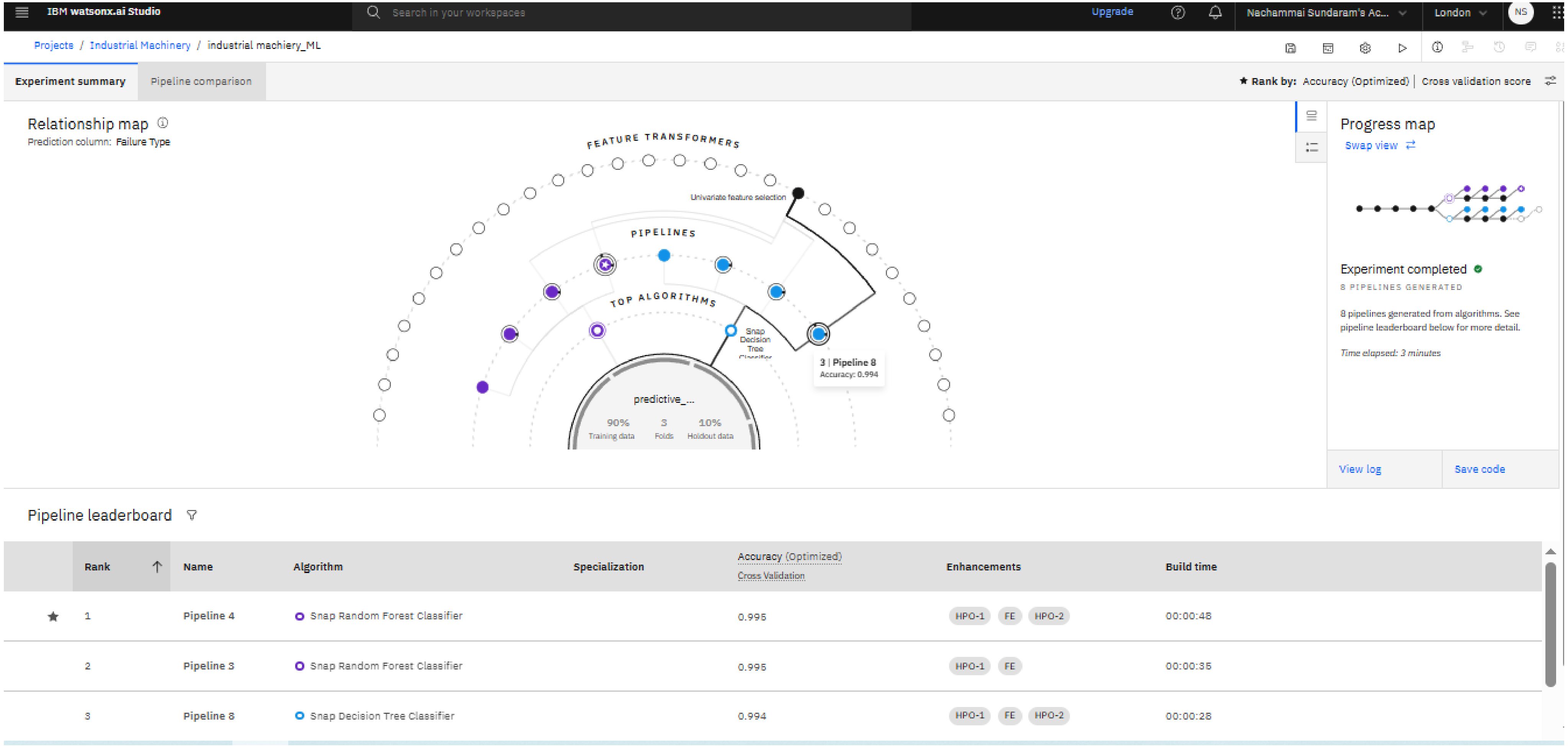
Training Process:

- The dataset was split into 90% training data and 10% holdout data.
- The training pipeline was generated automatically through AutoAI, which applied:
  - Pre-processing (normalization, missing value handling)
  - Feature Engineering
  - Hyperparameter Optimization (HPO-1, HPO-2)
  - Cross-validation (3 folds) to validate model performance

Prediction Process:

- The final model was deployed using IBM Watson Machine Learning **(WML)**.
- A REST API endpoint was created, allowing real-time input of sensor data to predict the failure type.
- The output includes both the predicted failure category and the confidence score for each prediction.

RESULT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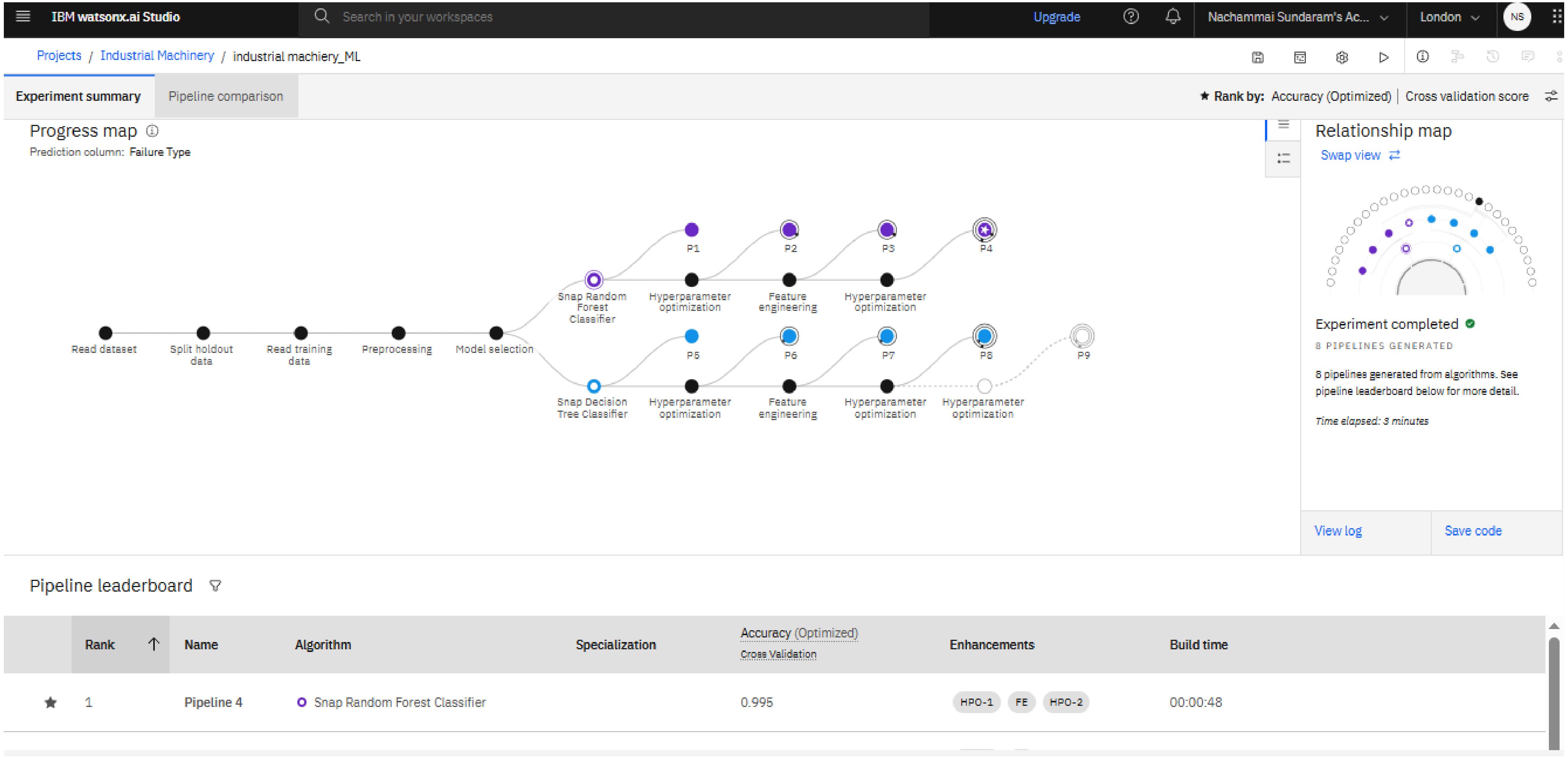
Experiment summary
Pipeline comparison
Rank by: Accuracy (Optimized) | Cross validation score
Relationship map
Prediction column: Failure Type
FEATURE TRANSFORMERS
Univariate feature selection
PIPELINES
TOP ALGORITHMS
Snap Decision Tree
3 | Pipeline 8
Accuracy: 0.994
predictive_...
90% Training data
3 Folds
10% Holdout data
Progress map
Swap view
Experiment completed
8 PIPELINES GENERATED
8 pipelines generated from algorithms. See pipeline leaderboard below for more detail.
Time elapsed: 3 minutes
View log
Save code
Pipeline leaderboard
Rank
Name
Algorithm
Specialization
Accuracy (Optimized) Cross Validation
Enhancements
Build time
1 Pipeline 4 Snap Random Forest Classifier 0.995 HPO-1 FE HPO-2 00:00:48
2 Pipeline 3 Snap Random Forest Classifier 0.995 HPO-1 FE 00:00:35
3 Pipeline 8 Snap Decision Tree Classifier 0.994 HPO-1 FE HPO-2 00:00:28

RESULT



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Experiment summary
Pipeline comparison
Rank by: Accuracy (Optimized) | Cross validation score
Progress map
Prediction column: Failure Type
Read dataset
Split holdout data
Read training data
Preprocessing
Model selection
Snap Random Forest Classifier
Snap Decision Tree Classifier
Hyperparameter optimization
Feature engineering
P1
P2
P3
P4
P5
P6
P7
P8
P9
Relationship map
Swap view
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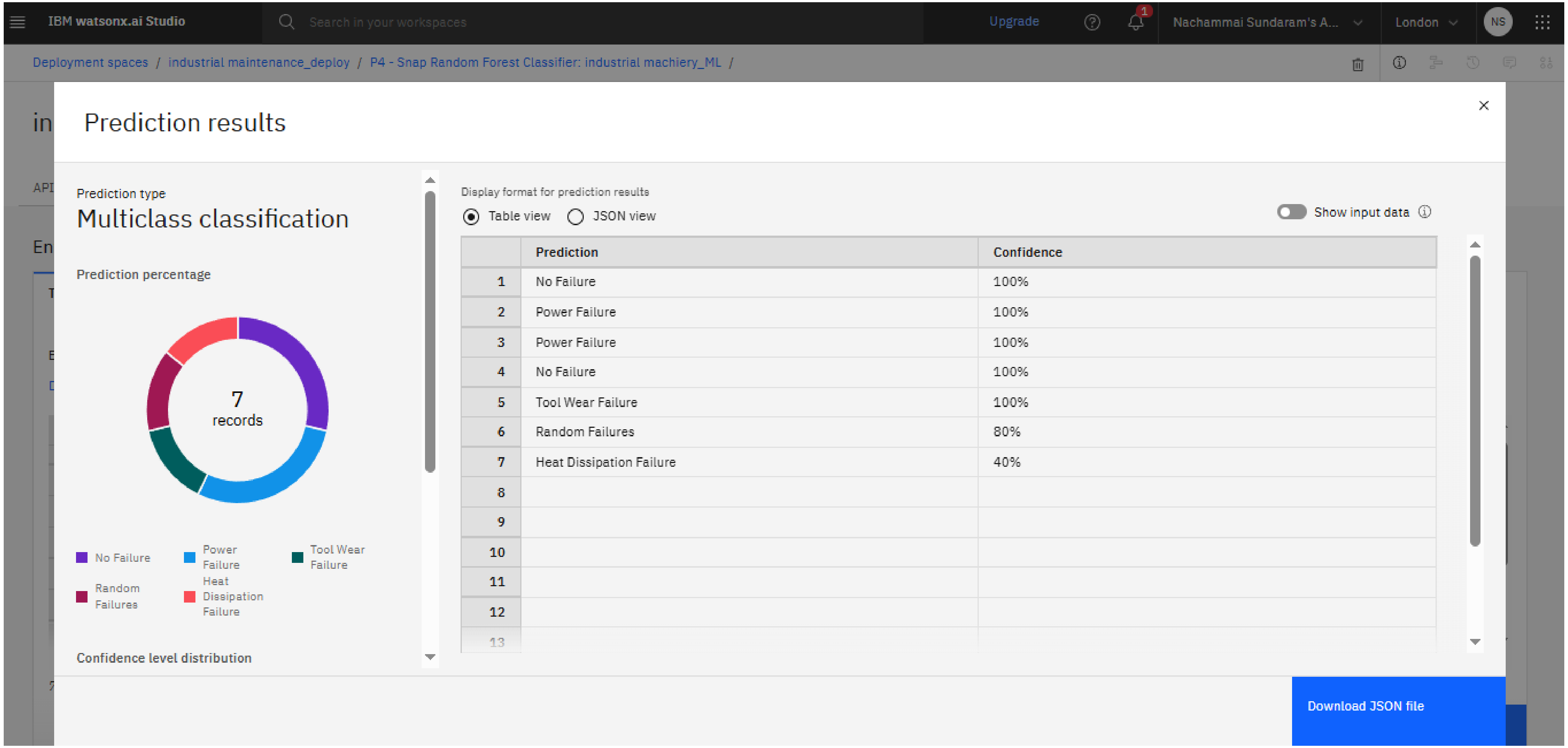
1
Pipeline 4
Snap Random Forest Classifier
0.995
HPO-1
FE
HPO-2
00:00:48

RESULT



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Deployment spaces / industrial maintenance_deploy / P4 - Snap Random Forest Classifier: industrial machiery_ML /
Prediction results
Prediction type
Multiclass classification
Prediction percentage
7
records
No Failure
Power Failure
Tool Wear Failure
Random Failures
Heat Dissipation Failure
Confidence level distribution
Display format for prediction results
Table view
JSON view
Show input data
Prediction
Confidence
1 No Failure 100%
2 Power Failure 100%
3 Power Failure 100%
4 No Failure 100%
5 Tool Wear Failure 100%
6 Random Failures 80%
7 Heat Dissipation Failure 40%
8
9
10
11
12
13
Download JSON file

CONCLUSION

- This project highlights the effectiveness of using a no-code machine learning platform for predictive maintenance in industrial environments. By leveraging IBM Watsonx.ai Studio on IBM Cloud, sensor data was efficiently analyzed, and the model accurately predicted different types of machinery failures, enabling proactive maintenance and minimizing downtime.
- One of the key advantages of this approach was the ability to build and deploy the model without writing any code, making it accessible to users with limited programming experience. Some challenges were faced during data preprocessing and understanding the model evaluation metrics, but the platform's built-in tools helped overcome these hurdles.
- The success of this model emphasizes the importance of accurate failure predictions in maintaining industrial efficiency, reducing operational costs, and supporting uninterrupted production workflows.

FUTURE SCOPE

- Incorporate additional data sources such as maintenance logs, environmental conditions, or production cycles to improve prediction accuracy.
- Expand the system to include different types of industrial machines and deploy it across multiple factories or regions.
- Integrate edge computing solutions to enable real-time, on-site failure detection and faster decision-making.
- Explore the use of advanced machine learning techniques as they become available in no-code/low-code platforms.

REFERENCES

- IBM Watsonx.ai Studio
- IBM Cloud Free Tier – Cloud infrastructure and services used for model deployment

IBM CERTIFICATIONS

- Screenshot / credly certificate(getting started with AI)

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IBM CERTIFICATIONS

- Screenshot/ credly certificate(Journey to Cloud)

Journey to Cloud: Envisioning Your Solution

In recognition of the commitment to achieve professional excellence

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Has successfully satisfied the requirements for:

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IBM CERTIFICATIONS

- Screenshot/ credly certificate(RAG Lab)

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